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Performance Payments for Groups: The Case of Carnivore Conservation in Northern Sweden

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Abstract This paper presents a first empirical assessment of carnivore conservation under a performance payment scheme. In Sweden, reindeer herder villages are paid based on the number of lynx (*lynx lynx*) and wolverine (*gulo gulo*) offspring certified on their pastures. The villages decide on the internal payment distribution. It is generally assumed that benefit distribution rules are exogenous. We investigate them as an endogenous decision. The data reveals that villages' group size has a direct negative effect on conservation outcomes and an indirect positive effect which impacts conservation outcomes through the benefit distribution rule. This result revises the collective action hypothesis on purely negative effects of group size.

Keywords Performance payments · Group payments · Wildlife conservation · Empirical policy assessment · Sweden · Lynx · Wolverine

1 Introduction

Conservation performance payments constitute a fairly new approach within environmental policy design. This paper investigates the determinants of variation in outcomes of such an approach for carnivore conservation across Sami villages in Sweden. Performance payments can be placed within the larger group of payments for environmental services (PES).

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Their distinguishing characteristic is that incentives are tied to indicators of environmental outcomes. Other more conventional PES schemes, by contrast, often tie payments to the provision of inputs into the production process of an environmental good (Engel et al. 2008), which may cause distortion.

The most prominent advantage of the performance payment approach is that the conditionality on the provision of environmental outcomes provides very direct incentives, leaving maximum flexibility and room for innovations in the production process of the good (Musters et al. 2001; Gorddard et al. 2008). Furthermore, direct performance payments are, under plausible conditions, found to be more cost-effective than other less direct conventional approaches (Ferraro and Simpson 2002; Wätzold and Drechsler 2005).

Challenges in scheme design arise when the identification of undistorted performance indicators is intricate, or secondary goals such as targeting payments to the poor need to be met. Additionally, allocating payments for mobile environmental goods such as wildlife or water to individuals may prove difficult (Haaren and Bathke 2008). When the performance indicator is only observable at the group level, it may be easier instead to allocate payments to the corresponding group, such as a village. The responsibility for finding a suitable internal payment distribution mechanism devolves to the group, thus creating a collective action problem.

Previous work on performance payment schemes for wildlife conservation has mainly been descriptive (e.g. Nelson 2009; see Dickman et al. 2011 for a review on literature covering financial incentives for predator conservation). Zabel and Holm-Müller (2008) present an overview of the Swedish performance payment scheme for carnivore conservation. Several further studies suggest testing the performance payment approach as a new strategy to mitigate carnivore-livestock conflicts (Muhly and Musiani 2009; Nyhus et al. 2005). To our knowledge, the only theoretical investigation compares the incentives generated in a conservation performance payment scheme to those of a simple livestock compensation scheme (Zabel et al. 2011). They find that both approaches can theoretically provide sufficient incentives for a livestock herder to let a carnivore population increase to the social planner's optimum. In addition to theoretical investigations, empirical evaluations of conservation policies are important to facilitate learning from existing schemes and to improve the development of new schemes. However, quantitative evaluation studies for conservation policies are fairly rare (Ferraro and Pattanayak 2006; Ferraro and Gjertsen 2009). Pattanayak et al. (2010) review impact evaluations of PES programs but an empirical assessment of a larger conservation performance payment scheme is still lacking (Abensperg-Traun 2009; Milne and Niesten 2009).

The Swedish policy investigated in this paper collectively rewards Sami villages, i.e. groups of reindeer herders, for increases in the carnivore population on the village's territory. We hypothesize that the variation in conservation outcomes across villages can be determined by (1) each village's ability to engage in collective action to solve the common pool resource dilemma, (2) the modalities of distributing the performance payment within the village, and (3) the natural environment.

Since the Swedish policy issues rewards for carnivore conservation to villages, the villages' residents are required to manage the use or distribution of the money. The previous literature on common pool natural resource management (CPNRM) problems has generally assumed that benefit distribution rules are exogenously given (e.g., Ostrom 1990; Agrawal 2001). This paper adds to the theoretical concepts of CPNRM regimes by revisiting this assumption. A model to explore how a group decides internally on the allocation of resource benefits is developed. The hypotheses developed are tested with village and household-level data collected in Sweden from participants in the first large-scale performance payment

scheme for carnivore conservation. The contribution of this paper is twofold: it adds to the theoretical conceptions of common pool resource management problems and has particular policy relevance because it is an empirical assessment of a rare example of a performance payment scheme targeting biodiversity conservation. Understanding the factors driving the success or failure of this type of scheme is crucial for designing similar policies elsewhere.

The remainder of the paper is organized as follows: Section 2 outlines the Swedish performance payment scheme. Section 3 discusses the theoretical concepts according to which variation in conservation outcomes across villages are assessed. The empirical investigation conducted in Sweden during 2008 and 2009 is presented and discussed in Section 4. The last section concludes the paper.

2 The Swedish Performance Payment Scheme for Carnivore Conservation

Many large mammals, including carnivores, are globally endangered (Hilton-Taylor et al. 2009). On the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, wolverines (*gulo gulo*) are categorized as near threatened and lynx (*lynx lynx*) are listed in the category 'least concern'. Lynx are also listed as a protected fauna species in Annex III of the Bern Convention.

The Swedish government has set explicit population numbers as benchmark goals for its lynx and wolverine conservation policy. The goal for the reindeer herding area in northern Sweden, which covers approximately two-thirds of the country, is to have 90 wolverine offspring and 80 lynx offspring annually. These offspring numbers correspond to a total population of approximately 400 wolverines and 400 lynx. On a national level, i.e. including regions beyond the reindeer herding area, the goal is to have 300 lynx offspring, corresponding to a total population of 1,500 lynx (Swedish Government Bill 2000).

Participants in the performance payment scheme are indigenous Swedish Sami reindeer herders. The carnivores' habitat overlaps with the grazing grounds of their semi-domesticated reindeer. During winter, the diet of wolverines and lynx consists to a large extent of reindeer (Pedersen et al. 1999). On average, each lynx and wolverine is estimated to annually prey on 40 reindeer (Swenson and Andrén 2005), causing major economic losses to the reindeer herders (Persson 2005; Swenson and Andrén 2005; Danell et al. 2006). Reindeer herding is of central importance to the Sami people and has for centuries been deeply rooted in their culture. The herders are organized into 51 Sami villages[1], which are located from north of the Arctic Circle to the more southern county of Dalarna. The reindeer are husbanded in a nomadic herding system; they move from the coastal areas in winter to the mountainous regions closer to the Norwegian border in summer. The reindeer herders have grazing rights to private lands and forests. In this herding system, reindeer are rarely kept in protected corrals, rendering them fairly easy prey for carnivores. Other non-Sami people also live in the regions covered by the Sami villages. Until 1996, a conventional compensation policy was in place. To claim compensation, the herders were required to find the carcass of a reindeer killed by a carnivore. Because searching for dead reindeer was cumbersome and this approach did not provide direct incentives for carnivore conservation, it was replaced by a performance payment scheme. Under this plan, searching for reindeer carcasses is unnecessary; instead, the carnivores have to be inventoried each winter. This is done in cooperation between herders and rangers and carried out according to very detailed regulations.

[1] The term 'Sami village' refers to a community of reindeer herders, but also to the geographical area where a community has grazing rights, but not property rights. In the following, the term will refer to the community.

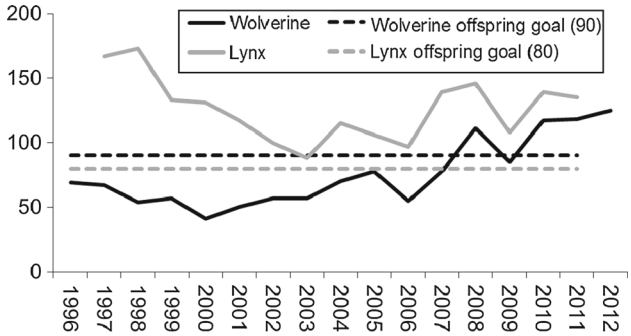

Fig. 1 Development of lynx and wolverine offspring in Swedish Sami villages Data sources: (Viltskadecenter 2009a, b, 2010, 2011, 2012a, b; Andrén and Liberg 2008)

The amount of the performance payment (SEK 200,000 per offspring, SEK 1≈ USD 0.15) is computed to, on average, compensate slightly more than the damage a carnivore is expected to cause during its lifetime. Apart from simply compensating damage, tying the payment to the number of offspring is intended to provide pro-conservation incentives, i.e. incentives not to hunt. Long-term studies with radio-collared animals which started prior to the policy change found that illegal poaching was a serious issue that impacted wolverine and lynx conservation (Persson 2007; Andrén et al. 2006).

To acknowledge the hardship that carnivore attacks can impose on the reindeer herding business, the current policy allows for limited 'protective hunting'. The Sami villages can apply for permission to hunt certain individual animals that cause excessive damage. Given the different conservation status of wolverines and lynx, protective hunting permissions are granted more restrictively for wolverines than for lynx. The government decreed that lynx should continue living in the reindeer herding area, but that only 80 of the national goal of 300 offspring need be in this area, while the larger part of the population should be spread across southern Sweden (Swedish Government Bill 2000). Wolverines thrive in undisturbed mountain terrain, which implies that the core population will inevitably be in the reindeer herding area. Figure 1 depicts the development of lynx and wolverine offspring, aggregated for all Sami villages, since the start of the performance payment scheme. The number of certified lynx offspring has been above the policy's benchmark for more than a decade. The number of wolverine offspring passed the conservation goal for the first time in 2008. However, there is substantial variation in the number of lynx and wolverine offspring between villages.

3 Theoretical Concepts

Two major issues are assessed in this paper: (1) whether conservation outcomes at the village level are a function of collective action and (2) what determines villages' internal benefit distribution rules, which themselves are hypothesized to aid in explaining conservation outcomes. Collective action is defined as an "action taken by a group (either directly or on its behalf through an organization) in pursuit of members' perceived shared interests" (Marshall 1996, p. 64). In the Swedish context, the reindeer herders need to engage in collective action to refrain jointly from poaching carnivores and to solve the common pool resource problem which arises when the state issues performance payments to the various villages

and devolves decisions about further use and distribution of that money to village members. A village will try to optimize its collective net benefit of performance payments subtractive of the cost of reindeer losses. For a rational *homo oeconomicus*-type herder, the decisive question will be whether his personal cost-benefit ratio is better with or without a marginal carnivore. The herder can then choose to work cooperatively with the other members of the village or diverge from the collective decision. We test the hypothesis that the conservation outcome at the village level, measured in numbers of carnivore offspring, is determined by natural geographical factors and the villages' potential to solve the common pool resource problem.

Concerning the second issue, in the literature, benefit distribution rules have generally been assumed to be exogenously given[2] (Ostrom 1990; Agrawal 2001). The conceptual contribution of this paper, presented in Sect. 3.2, is to explain the allocation rule as a variable endogenously determined by the reindeer herders in each village.

3.1 Determinants of Collection Action for Conservation Success

Collective action theory compiles factors that are hypothesized to impact the outcomes of CPNRM problems (see Agrawal 2001 for a summary of this literature). To analyze the Swedish scheme, the following factors are of particular importance: (1) group size; (2) heterogeneity; (3) exit options; (4)social capital; (5) resource system characteristics; and (6) institutional arrangements.

3.1.1 Group Size

Members of smaller groups or communities often have multiple interrelationships and repeatedly interact with each other. Individuals' actions are more observable in small, close-knit societies than in larger, more anonymous communities (Baland and Platteau 1996). These features are hypothesized to reduce incentives to defect from contributing to collective action because members of small groups are more likely to reflect on the long-term aftermath and reputation effects of their actions than merely the short-term gains (Baland and Platteau 1996). Agreements may also be easier and less costly to reach in small groups since the costs of communicating and bargaining are lower (Olson 1965). These considerations support the hypothesis that small group size is beneficial for collective action. On the other hand, extremely small groups are hypothesized to exhibit low levels of collective action due to prohibitively high fixed costs of organizing collective effort (Gebremedhin et al. 2004).

In the Swedish Sami villages, the number of reindeer enterprises within each village can be used as a proxy for group size. Since organizational structures already exist in all villages, costs to initiate collective action are unlikely to be prohibitively large, even in very small villages. We expect instead the effects of personal interrelationships to dominate, so that conservation success is negatively impacted by group size.

3.1.2 Heterogeneity

With respect to the provision of public goods, Olson (1965) suggests that some degree of heterogeneity is beneficial because otherwise no one would take a lead in managing the

[2] A step towards endogenizing benefit contribution within local communities is made in the Engel (2005) game-theoretic model of community-based irrigation management in Ghana. Payoffs in her model depend on land distribution and the distributional rule for maintenance costs. Land distribution is modelled as an endogenous outcome based on consensus and are shown to depend on the (exogenous) cost distribution rule.

resource in question. By contrast, Baland and Platteau (1999) suggest that while agents with greater endowments and a larger stake in the conservation of a resource may be incentivized to conserve a common property resource, agents with smaller endowments and a lesser stake in the resource may have fewer incentives to do so. As inequality in endowment increases, establishing and adhering to rules for collective action of common property management becomes more difficult. Likewise, differences in asset ownership or wealth can give rise to feelings of envy or rivalry, which may negatively affect collective action. Such effects can be especially disruptive in small groups (Baland and Platteau 1996).

In the Swedish case, an individual's endowment is linked to the size of his reindeer herd. Differences in management interests can arise with heterogeneity in reindeer ownership. According to Baland and Platteau's theory, this heterogeneity may also be an indicator for problems of envy and rivalry, which could hamper finding solutions for the management of the performance payments. If such intra-community problems are severe, applying for protective hunting may be a less onerous solution than conserving many carnivores on the village's territory. A negative relationship between heterogeneity and conservation success is thus likely. The empirical analysis will show whether the data support Baland and Platteau's or Olson's theory. At the village level, heterogeneity of reindeer ownership can be measured by a Gini index. An index value of zero indicates that all reindeer enterprises have an equal number of reindeer; the more unequal the number, i.e. the more concentrated reindeer ownership is, the closer the index value moves to one.

3.1.3 Exit Options

Exit options refer to possibilities of deriving income or the means of living from sources beyond the resource at question. The classical hypothesis is that group members who do not or cannot make use of exit options have strong incentives to work towards a sustainable use of the resource (Ostrom 1990; Agrawal 2001). Members whose livelihoods are not bound to the local resource may have less interest in its long-term use (Baland and Platteau 1996).

In Sweden, exit options can be measured as the percentage of working time that reindeer owners spend outside the reindeer business. An average of this percentage can be used to obtain a village-level variable. Part-time reindeer herders naturally have less time to protect their reindeer from carnivore attacks and as a consequence are likely to incur higher losses. Thus, villages in which on average herders are heavily engaged in outside jobs may be more likely to apply for protective hunting, which reduces conservation success. By contrast, villages with many full-time herders are likely to incur fewer reindeer losses per carnivore and so may be willing to host more of them. Villages can apply for protective hunting permission at the nature conservation agency. The agency evaluates the applications on a case-by-case basis. Generally, permissions have been granted quite generously for lynx but very cautiously for wolverines because of the differences in their conservation status.

3.1.4 Social Capital

In recent years, the interest in social capital as a factor enhancing collective action has greatly increased. Putnam (1995) defines social capital as features of social organization which can help to advance cooperation for mutual benefit and help resolve problems of collective action. Examples for such facilitating features are networks, norms, and social trust, which can simplify coordination and amplify reputations (Putnam 1995). Field (2003) states that in Putnam's view social capital contributes to collective action by raising the costs of defection,

strengthening reciprocity, enhancing exchange of information on people's reputation, and providing a pattern for future cooperation.

With respect to the Swedish context, Putnam's proposition supports the hypothesis that social capital in a reindeer herder village may have a positive impact on conservation success as an outcome of collective action. Social cohesion can function as a proxy for social capital. Social cohesion can be measured by asking for opinions on statements such as whether 'most members of a village are interested in the villagers' common welfare and only a few are interested solely in their private welfare'. Scores can be attributed to given answer categories to indicate a range from low to high perceived social cohesion (Krishna 2004). Scores can be averaged over villages to obtain village-level variables.

3.1.5 Resource System Characteristics

The largest variation in resource system characteristics in the Sami villages is their topography. The villages in the north and west have predominantly mountainous terrain with no tree cover at high altitudes, whereas southern and eastern villages are less mountainous but have more forest cover. These natural geographical distinctions are important because wolverines live in mountainous habitat and lynx mainly stay in the forest. GIS data can be used to obtain information on the square kilometers of mountainous and forested area in each village.

3.1.6 Institutional Arrangements

The prominent question concerning institutional arrangements is how the group members decide to use or distribute the benefits of the common pool resource, which in the Swedish case is the performance payment that can either be invested for community expenses or distributed to individual reindeer herders. The existing collective action literature has paid little attention to this question. However, since the benefit distribution rule is hypothesized to impact the outcomes of community-based natural resource management, it is important to understand the underlying mechanisms which lead to a particular distribution rule. The following section investigates this question at more depth.

3.2 Determinants of the Payment Distribution Decision

In previous literature, benefit distribution rules have generally been assumed to be exogenously predetermined (Ostrom 1990; Agrawal 2001). In many cases, this assumption may not reflect the prevailing circumstances particularly well. In practice, groups often autonomously design their benefit distribution rules. We hypothesize that the rule decided upon by the group is an outcome of its internal characteristics and dynamics. By disregarding questions of how a benefit distribution rule is established, researchers run the risk of missing important factors that may impact the outcome of common pool resource problems.

The payment distribution decision is explicitly for the performance payments and not for other income sources, if any[3]. Typical common investments are for maintenance of facilities, such as fences or cottages, and fees for helicopters to round up reindeer. If the payment is distributed to individuals, it is generally allocated according to herd size. However, there are two villages in which the money is paid per identified killed reindeer. Since the number of

[3] Other joint income sources can stem from the sale of seasonal fishing licenses, sale of reindeer calves that were not marked by the owners, or compensations from hydropower plants or windmill entrepreneurs for reductions in grazing land. These income sources are usually a lot smaller than the carnivore performance payments.

reindeer a herder loses, in the long run, is proportional to herd size, making payments based on killed reindeer can be interpreted as equivalent to issuing payments according to herd size.

We hypothesize that in a first step, each herder in a village computes the division of the money that would maximize his personal utility. In a second step, the herders then collectively negotiate the final division of the money. To determine an individual's optimal payment distribution we develop a simple Cobb–Douglas utility maximization model. In the model, the share of the total performance payment distributed directly to the individuals is termed α, and the share retained for community expenses is $1-\alpha$. A reindeer herder maximizes his utility, which is a function of his private income, R, and the community investment, C, both of which will depend on α:

$$U(\alpha) = R(\alpha)^{\gamma} C(\alpha)^{1-\gamma} \tag{1}$$

where the elasticities γ and $1-\gamma$ of the Cobb–Douglas function indicate an individual's preferences for private income versus community investments.
The herder's private income

$$R(\alpha) = p[F(x_i) - k(W)] + \pi_i + \alpha \frac{x_i}{X_T} V(W) \tag{2}$$

consists of the sum of revenue derived from the sale of reindeer meat, $p[F(x_i) - k(W)]$, his off-farm income, π_i, and his individual direct share of the performance payment money, $\alpha \frac{x_i}{X_T} V(W)$, where W is the number of carnivores, and $\frac{x_i}{X_T}$ is the individual's share of the village's total number of reindeer, X_T. To maintain a constant reindeer stock, x_i, the herder is assumed to only sell the net growth of his herd. This is determined by the growth of his stock $F(x_i)$, which is a logistic growth function, minus the number of reindeer that are killed by carnivores, $k(W)$, (with $\partial k/\partial W > 0$). The exogenous price of reindeer meat, net of management and slaughtering costs, is given by p.

The total performance payment issued to the village, $V(W)$, is a function of the carnivore stock, with $\partial V/\partial W > 0$. The amount of money directly given to the herder can then be computed as $\alpha \frac{x_i}{X_T} V(W)$.
The community investments are simply:

$$C(\alpha) = (1-\alpha) V(W) \tag{3}$$

With Eqs. (2) and (3) given, the herder maximizes his utility function specified in (1), or equivalently:

$$\max_a \ln U(\alpha) = \gamma \ln(R(\alpha)) + (1-\gamma) \ln(C(\alpha)) \tag{4}$$

The first order condition derived from (4) is:

$$\frac{\gamma}{R(\alpha)} R'(\alpha) = \frac{(\gamma - 1)}{C(\alpha)} C'(\alpha) \tag{5}$$

where the prime indicates the derivative. Given (2) and (3), Eq. (5) can be rewritten as:

$$\frac{\gamma \frac{x_i}{X_T} V(W)}{p[F(x_i) - k(W)] + \pi_i + \alpha \frac{x_i}{X_T} V(W)} = \frac{(\gamma - 1)(-V(W))}{(1-\alpha) V(W)} \tag{6}$$

Solving for α yields the herder's individual optimality condition:

$$\alpha^* = \gamma - \frac{(1-\gamma)[p(F(x_i) - k(W)) + \pi_i]}{\frac{x_i}{X_T} V(W)} \tag{7}$$

Once all herders have identified their personally optimal alpha, the village's choice of payment distribution is assumed to be based on voting. A special characteristic of the Sami villages is that they have a weighted voting system. The number of votes is allocated according to an individual's reindeer herd size, with one vote corresponding to one hundred reindeer. This is a similar system to shareholder meetings. Applying the median voter theorem (Cornes and Sandler 1996) to this special case implies that the village-level outcome will correspond to the 'median vote' rather than the median voter[4]. Equation (7) can be used to derive hypotheses on the determinants of the payment distribution rule that can then be empirically tested.

Hypothesis 1 Villages with comparatively higher carnivore populations are expected to allocate more of their performance payments directly to the individual herders. This hypothesis builds on the derivative of (7) w. r. t. W:

$$\partial\alpha_i/\partial W = (1-\gamma_i)X_T x_i^{-1}\left[V(W)^{-2}[p(F(x_i)-k(W))+\pi_i]+pV(W)^{-1}\partial k/\partial W\right] > 0,$$

which is always positive under the sufficient condition that growth of the reindeer stock is larger than predation $F(x_i) > k(W)$.

It suggests that an increase in a village's carnivore population is reflected in an increase in the performance payment and an increase in predation by carnivores. This will increase the optimal alpha for each villager and cause a shift in the preference distribution of all herders in a village towards a larger alpha. In consequence, the median vote holder will also opt for a larger alpha.

If the condition $F(x_i) > k(W)$ were not satisfied, the carnivores would gradually eliminate the reindeer population. By law, the carnivore population in Sweden may not rise to a level at which reindeer herding is no longer possible (Swedish Government Bill 2000).

Hypothesis 2 Villages in which the median vote holders have a higher preference for private income over community investments will, on average, allocate more of the performance payment directly to the herders. This can be seen from

$$\partial\alpha_i/\partial\gamma_i = 1+[p(F(x_i)-k(W))+\pi_i]X_T x_i^{-1}V(W)^{-1} > 0 \text{ for } F(x_i) > k(W).$$

We use the number of herders in a village as a proxy for the preference for private income. The larger a group is, the more difficult it may be to decide collectively on the use and distribution of common investments, thus increasing the preference for private income.

Hypothesis 3 Villages with many reindeer and a high concentration of reindeer ownership will, on average, allocate a larger share of the payment directly to the herders. The derivative of alpha with respect to an individual's herd size

$$\partial\alpha_i/\partial x_i = X_T V(W)^{-1}(1-\gamma_i)\left[x_i^{-2}(p(F(x_i)-k(W))+\pi_i)-px_i^{-1}\partial F/\partial x_i\right]$$

is always positive under two sufficient conditions: growth being larger than predation, $F(x_i) > k(W)$, and marginal growth being negative, $\partial F/\partial x_i < 0$. The latter is likely to apply to the Swedish case because each village has a state-defined quota for total herd size, which represents each village's reindeer-carrying capacity. The villages' total herd sizes are close to the quota. The existence of the quota also explains why herd size is not a function of carnivores.

[4] In practice, the villages only take a formal vote if there is a dispute and otherwise agree by consensus during their annual meetings, or "stormöte".

We hypothesize that villages in which some herders have very large numbers of reindeer will, on average, opt for a larger alpha. The concentration of reindeer ownership at the village-level can be expressed through a Gini coefficient. We hypothesize that an increase in the Gini coefficient is associated with an increase in alpha.

Hypothesis 4 More of the performance payment will be allocated directly to herders if there is inequality of losses to carnivore attacks on a village's winter pastures. In many villages, the reindeer are split into smaller groups during winter. For example, some may be closer to a forest and more prone to carnivore attacks than on a pasture close to a settlement. The variable δ_v takes the value 1 if there are systematic inequalities in carnivore attacks on different winter pastures and zero otherwise[5]. This hypothesis is not directly based on Eq. (7). However, it implies that more of the payment will be distributed directly to herders if some suffer proportionally higher losses than others in the village.

Equation (7) contains two further parameters that can impact an individual's optimal alpha. First, a marginal increase in off-farm income decreases an individual's optimal alpha $\partial\alpha_i/\partial\pi_i = -X_T(1-\gamma_i)/x_i V(W) < 0$. Unfortunately, it is not possible, from this individual-level variable, to infer possible changes in the overall village-level preference distribution for alpha. It is thus not possible to make a statement on whether and in which direction the median vote for alpha would shift.

Second, an increase in reindeer meat price would increase an individual's optimal alpha, i.e. he would prefer to personally obtain a larger share of the performance payment $\partial\alpha_i/\partial p = -X_T(1-\gamma_i)(F(x_i)-k(W))/x_i V(W) < 0$ if $F(x_i) > k(W)$. However, there is no substantial variation in reindeer meat prices across villages.

Since alpha, the share of money allocated to the herders, has corner solutions at 0 and 1, we apply a Tobit regression to test our hypotheses empirically. The Tobit model can be specified as follows,

$$\begin{aligned} \mathrm{A}_v^* &= \beta_0 + \beta_1 W_v + \beta_2 \gamma_v + \beta_3 \chi_v + \beta_4 \delta_v + u_v \\ \mathrm{A}_v &= \max(\mathrm{A}_v^*, 0) \end{aligned} \tag{8}$$

where A_v is the observed value for the share (α) of money given to the herders in village v. A_v^* is the latent variable and $u_v(0, \sigma^2)$ is the normally-distributed error term. χ_v is a Gini coefficient expressing the inequality or concentration of herd sizes in a village, and δ_v is a dummy variable reflecting inequalities of damage, i.e. carnivore attacks on different winter pastures in one village. Based on the hypotheses developed above, we expect all four coefficients $\beta_1, \beta_2, \beta_3, \beta_4$ to be positive.

Figure 2 below summarizes the framework of our empirical assessment. The determinates of collective action were discussed in Section 3.1 while Section 3.2 laid a special focus on investigating the payment distribution rule.

4 Empirical Analysis

The data required for the analysis of the Swedish performance payment scheme for carnivore conservation were collected in two steps. In each village, one reindeer herder is designated to be the village's carnivore representative. This person attends meetings on carnivore issues and is the contact person and mediator for all carnivore matters vis-a-vis the government. From August to October 2008, structured interviews were conducted with the carnivore representatives of all villages, except one who refused to participate in the study. The interviews

[5] Lacking continuous data we use a binary variable which can pick up less variation in the data.

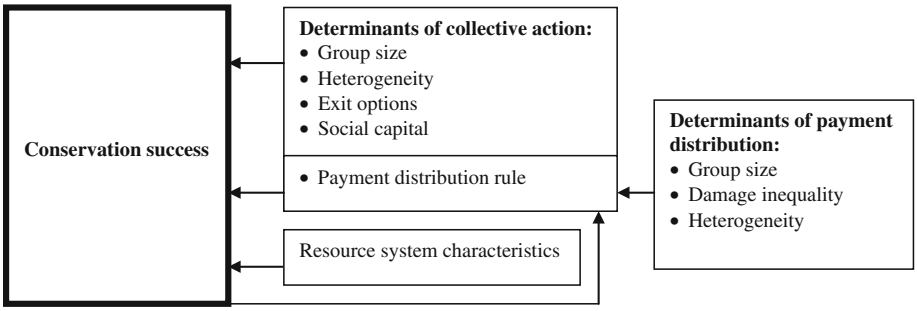

Fig. 2 Framework for empirical assessment of conservation success under a performance payment scheme

were all conducted by one of the authors and in most cases took place in the interviewees' homes.

The household-level data was obtained through a mail survey. In February 2009, the survey was sent to a sample of 970 registered reindeer owners between 18 and 65 years of age, and in April a reminder was sent to all who had not yet responded. The sample population represents 25.3 % of the total number of reindeer owners in this age cohort. The sample was stratified according to the villages' population. The final response rate obtained was 41.3 %. Concerning representativeness of the responses, we find that there is no significant difference between the mean age of the respondents (45.88 years) and the mean age of the sample population (46.12 years). The gender distribution of the respondents (59 % men, 41 % women) is not significantly different from that of the total population of Swedish reindeer herders (62 % men, 38 % women) (Sametinget 2009). Furthermore, 84.5 % of the sample population belongs to Sami villages in the county of Norrbotten, 7.6 % to Västerbotten, and 7.8 % to Jämtland. This regional division was also well-reflected in the responses and not significantly different from the sample: 86.9 % of the responses came from villages in Norrbotten, 6.03 % from Västerbotten, and 7.04 % from Jämtland.

According to the theoretical framework outlined in Figure 2 and discussed above, we conduct econometric analyses to explain the payment distribution rule and variation in conservation success at the village level under a performance payment scheme. Table 1 provides a summary overview of the variables used. The data we collected represents one point in time. Although the policy has been in place for more than a decade, data availability necessitates a cross-sectional approach.

The dependent variables for conservation success are measured as the total number of lynx and wolverine offspring, respectively, per village that were certified between 1996 and 2006. The key variable indicating the villages' payment distribution decision is the percentage of the payment directly distributed to the herders ('Share_herders'). Figure 3 depicts this variable's distribution. The distribution has three spikes, at 0 % (i.e. none of the performance payments are allocated directly to the individual herders), 50, and 100 % (i.e. all of the performance payments are allocated directly to the individual herders). As noted above, any remaining share of the money is used for common investments such as maintenance of fences or expenses for helicopters to round up reindeer.

Herd size data were obtained from secondary information on all enterprises in a village. Unfortunately, the data on herd size is not available for seven villages located in the northeast of Sweden, near the border with Finland [6].

[6] This bears the risk of biasing the results. We will therefore conduct the analysis below both with and without variables related to herd size

Table 1 Variables used in the analysis of the Swedish performance payment scheme

VARIABLES		Mean	Std. Dev.	Min	Max	N
Lynx	Lynx offspring 1996–2006 per village	33.39	35.55	0.00	141.50	50
Wolverines	Wolverine offspring 1996–2006 per village	13.92	15.99	0.00	63.23	50
Share_herders	Percentage of performance payment allocated to individuals directly in each village	0.44	0.39	0.00	1.00	50
Group_size	Number of reindeer enterprises in each village	35.17	43.74	2.00	220.00	50
Gini_herd	Gini index measuring heterogeneity resp. concentration of reindeer ownership in each village	0.39	0.16	0.02	0.66	43
Exit_option	Average for each village of respondents' percentage of working time spent outside reindeer herding sector	58.08	24.86	0.00	87.50	49
Social_capital	Average score for perception of cohesion in each village (1=high, 5=low perceived cohesion)	2.68	0.77	1.00	4.33	49
Carnivores	Sum of lynx and wolverine offspring per village 1996–2006	47.30	40.20	0.00	158.99	50
Damage_inequality	Dummy indicating if carnivore attacks are systematically more severe on some of a village's winter pastures than on others			0.00	1.00	50
Forest	Forested area per village in units of 1000 square kilometers	2.76	2.27	0.14	9.33	50
Mountain	Mountainous area per village in units of 1000 square kilometers	0.68	0.72	0.00	3.06	50
Forest_mountain	Sum of forested and mountainous area per village in units of 1000 square kilometers	3.44	2.51	0.55	10.20	50

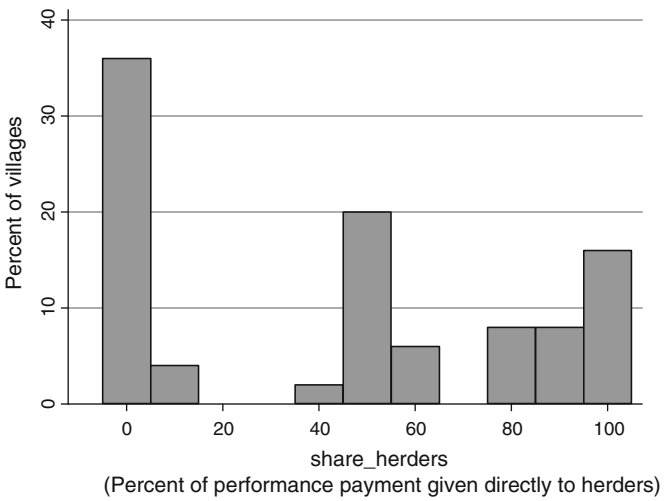

Fig. 3 Empirical distribution of the variable 'share_herders' (alpha)

The availability of exit options is approximated as the average percentage of working time that respondents spent outside of the reindeer herding sector during the past year. The proxy for social capital is computed as a village-level average that is based on responses from the household survey. Respondents were asked to indicate their opinion on the statement that most members in their village are interested in their common welfare and only a few are solely interested in their private welfare. To obtain data for the variable on damage inequality, the carnivore representatives of each village were asked whether all herders suffer proportionally equal reindeer losses in winter. Village's forested and mountainous areas are used as proxies for natural geographic characteristics because the lynx habitat is the forest and wolverines prefer mountains.

4.1 Test of Model for Payment Distribution Decision

The empirical data allows for a test of the model on the village internal payment distribution decision developed in Section 3.2. Table 2 presents the results for the instrumental variable Tobit models. An instrumental variable approach is necessary because we hypothesize that the number of carnivore offspring, i.e. conservation success, is also an outcome of the payment distribution rule. The instrument chosen is the sum of forested and mountainous area in each village. In brackets behind the names of the independent variables are the model parameters that are being proxied and their predicted sign.

Table 2 Results of village-level IV-Tobit analysis for 'Share_herders', i.e. the percentage of performance payments directly distributed to the reindeer herders. The dependent variable for the 1st stage is 'Carnivores'

Variables	2a		2b	
	1st stage	IV tobit	1st stage	IV tobit
Carnivores (W,+)		0.004		0.005
		(0.004)		(0.004)
Group_size (γ,+)	−.576***	0.012**	−.308***	0.010***
	(0.211)	(0.005)	(0.089)	(0.003)
Gini_herd (χ,+)	4.116	−0.145		
	(31.254)	(0.652)		
Damage_inequality (δ,+)	16.930*	0.346	13.477	0.427**
	(9.315)	(0.211)	(8.242)	(0.211)
Forest_mountain (+)	9.450***		9.228***	
	(1.827)		(1.547)	
constant	17.576	−0.383	17.080*	−0.563*
	(12.196)	(0.292)	(8.997)	(0.293)
N		43		50
Log likelihood		−236.116		−274.181
Pseudo-R^2		0.36		0.36
left-censored		16		18
uncensored		22		24
right-censored		5		8

Standard errors in parenthesis
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The model presented in column 2a tests all four hypotheses developed in Section 3.2. Only the coefficient for group size is significant and has the expected sign. Apart from the coefficient for the Gini index, which proxies the concentration of reindeer ownership, the other variables' coefficients have the expected sign but are not significant. Unfortunately, for several villages there is no data available on the variable 'Gini_herd'. Column 2b thus presents the same model but without this variable. There, the coefficients remain largely unchanged, with only the significances for group size and damage inequality increasing.

Referring to the hypotheses set up in Section 3.2, we thus cannot reject hypotheses 2 and 4 but do reject hypotheses 1 and 3. The results suggest that group size, which in terms of our model proxies the preference for private income, is an important factor determining the payment distribution rule. Costs of negotiating on community expenditures are likely to increase with group size. High negotiation costs in turn render private income preferable over community investments. Furthermore, it is notable that the absolute number of carnivores seems to be of lesser importance, while inequalities of damage on winter pastures within a village has an impact on the payment distribution rule.

4.2 Variation in Conservation Across Villages

Conservation outcomes, measured in numbers of offspring, are hypothesized to be a function of collective action within a village, a village's payment distribution rule, and its natural geographic features. The models for lynx and wolverine conservation are presented in Tables 3 and 4. The first column in both tables is a theory-driven model where the payment distribution rule is hypothesized to depend endogenously on the conservation outcome. This endogeneity assumption is derived from the model developed in Section 3.2. A two-stage least squares (2SLS) approach is applied to account for endogeneity. In the tables below, column (a) presents the results of the first stage and column (b) the results of the instrumental variables regressions. The instrumental variable for the share of money distributed directly to herders is 'Damage_inequality', i.e. systematic differences in severity of carnivore attacks on different winter pastures. However, the results of Wu-Hausman-tests for the 2SLS regressions in Table 3 ($F(1,33) = 0.9244$) and Table 4 ($F(1,33) = 0.5825$) both indicate that the payment distribution variable ('Share_herders') is not endogenous. This finding is in accordance with the finding that the variable 'Carnivores' was not significant in Table 2 of Section 4.1.

Column (c) in both tables thus presents an OLS regression model in which the payment distribution rule is treated as an exogenous variable. Since we are lacking data on the Gini index for seven villages, we also ran these OLS regression models without this variable. Eliminating the Gini index as an explanatory variable did not produce major changes in parameter results for the other variables. Column (d) in both tables presents OLS regression results for a model including only the natural-geographical variable 'or 'Mountain', respectively.

In a first step we conduct F-tests to assess whether the socio-economic variables together significantly aid in explaining more of the variance in conservation success than simply the natural-geographic variables. The tests reveal that in the lynx case ($F(5,34) = 2.57$), the addition of the socio-economic variables significantly improves the model's explanatory power, whereas in the wolverine case ($F(5,34) = 0.78$) it does not. These results are reinforced by the results of Ramsey RESET tests which test for omitted variables (Cameron and Trivedi 2009). For the wolverine model in column (d) of Table 4 the test indicates that there are no omitted variables ($F(3,45) = 2.31$). The corresponding test for the regression of 'Lynx' on 'Forest' in Table 3 ($F(3,45) = 6.98$) states that there are omitted variables.

Table 3 Results for the analysis of lynx conservation

VARIABLES	(3a) 2SLS (first stage)	(3b) 2SLS	(3c) OLS	(3d) OLS
	Share_herders	Lynx	Lynx	Lynx
Share_herders (+/−)		69.35*	31.80**	
		(41.691)	(13.320)	
Group_size (−)	0.006**	−0.835**	−0.570**	
	(.003)	(.373)	(0.245)	
Gini_herd (−)	0.024	−37.56	−36.45	
	(.411)	(34.107)	(33.701)	
Exit_option (−)	0.0001	−0.215	−0.232	
	(.002)	(.195)	(0.192)	
Social_capital (−)	0.073	−4.247	−1.325	
	(.069)	(6.577)	(5.750)	
Forest (+)	0.015	6.858***	7.377***	8.526***
	(.025)	(2.125)	(2.030)	(1.898)
Damage_inequality (+)	0.244*			
	(.123)			
Constant	−0.166	45.45*	45.84**	9.823
	(.274)	(21.516)	(21.269)	(6.760)
Observations	41	41	41	50
R-squared	0.301	0.369	0.489	0.296
Adj. R-squared	0.178	0.258	0.398	0.281

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

4.3 Results

The findings of the F-tests and omitted variable tests point to important policy differences between lynx and wolverine management. For lynx, legal hunting permissions have been granted quite generously because the government has decreed that the total lynx population may decrease in the reindeer herding area. This supports the implication that our regression models show collective action factors that impact the decision on legal lynx population management within the villages.

The important policy difference in the wolverine case is that permissions for protective hunting have been granted only on a highly restrictive basis. Although it may seem likely that the factors impacting the villages' lynx population-management decisions also apply in the wolverine case, they do not. The variable 'Group_size' is significant and has the hypothesized negative sign. The Gini index is also significant but does not have the expected sign. However, an F-test for a comparison of model (4c) with and without these two variables ($F(2,34)=1.69$) reveals that their addition does not significantly improve the explanatory power of the model. The main factor impacting variation in wolverine conservation across villages is abundance of mountainous area. This single variable can explain nearly three-fourths of the variation. Since we cannot detect a significant impact of socio-economic variables, the data allows for the conclusion that the herders, by and large, let the wolverine population develop naturally, i.e. they refrain from illegal poaching.

Table 4 Results for the analysis of wolverine conservation

VARIABLES	(4a) 2SLS (first stage)	(4b) 2SLS	(4c) OLS	(4d) OLS
	Share_herders	Wolverines	Wolverines	Wolverines
Share_herders (+/−)		−10.11	−0.253	
		(13.288)	(3.984)	
Group_size (−)	0.005*	−0.109	−0.169**	
	(0.003)	(0.105)	(0.072)	
Gini_herd (−)	0.071	25.47**	24.96**	
	(0.388)	(9.362)	(9.442)	
Exit_option (−)	−0.0003	−0.008	0.001	
	(0.002)	(0.057)	(0.057)	
Social_capital (−)	0.074	0.190	−0.599	
	(0.069)	(1.967)	(1.703)	
Mountain (+)	0.061	20.368***	19.5***	19.221***
	(0.081)	(2.252)	(1.977)	(1.567)
Damage_inequality (+)	0.225*			
	(0.124)			
Constant	−0.137	−3.408	−3.549	0.844
	(0.268)	(6.129)	(6.193)	(1.548)
Observations	41	41	41	50
R-squared	0.305	0.744	0.783	0.758
Adj. R-squared	0.182	0.699	0.745	0.753

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The regression results for lynx conservation reveal that the variables 'Share_herders' 'Group_size', and 'Forest' have a significant impact. The coefficient for 'Share_herders' is positive, suggesting that issuing a larger fraction of the performance payment directly to herders, on average, is advantageous for lynx conservation. As hypothesized, group size has a negative impact on conservation outcomes. The larger the group, the less frequent are personal interrelationships between all members. Anonymity increases while the incentives to consider reputation effects may decrease. Additionally, as group size increases, communication and bargaining costs increase. These characteristics may decrease the benefits of conservation to such a degree that, for large groups, applying for permission to hunt a lynx becomes the preferable outcome. In other words, in large groups the costs of collectively agreeing to engage in conservation may be higher than the benefits derived from the performance payments, i.e. the performance payments subtractive of the cost of reindeer losses.

The abundance of tree-covered areas measured by the variable 'Forest' clearly has a positive and strongly significant impact on lynx conservation outcomes. The model in column (d) of Table 3 reveals that this variable alone captures nearly 30 % of the variation in the number of lynx offspring.

Although not significant, the collective action variables 'Gini_herd', which proxies heterogeneity, 'Exit_option', and 'Social_capital' all have the expected negative sign. According to the theory presented above, the negative sign for 'Gini_herd' may point to rivalry and envy, which increase with inequality of reindeer ownership and hamper collective action in the communities. Also in line with the theory, the negative sign for the social capital index

suggests that, on average, conservation success is lower in villages where members feel there is little community cohesion. The negative coefficient for 'Exit_option' indicates that when herders, on average, spend less time in the reindeer business, conservation success is lower.

5 Concluding Remarks

This paper has empirically assessed (1) whether differences in conservation outcomes across villages are a function of collective action and (2) what determines villages' internal benefit distribution rules for the first large-scale performance payment scheme for carnivore conservation. Concerning the first question, we hypothesized that variation in conservation success across villages is a function of the natural-geographic environment, collective action, and particularly the villages' decisions on how to allocate internally the monetary benefits of conservation, i.e. the performance payments.

The econometric analysis on cross-village differences in wolverine conservation outcomes revealed that the abundance of mountainous area, which is wolverines' preferred habitat, is the most important single factor impacting the number of wolverine offspring. The collective action variables did not significantly add to the explanation of variation in conservation outcomes.

Contrary to the wolverine case, socio-economic variables did significantly add to the explanation of variation in lynx conservation outcomes among villages. We ascribe this difference to the fact that applications for protective hunting of lynx were granted quite generously. Essentially, the outcome of the decision on whether to apply for protective hunting or to let the carnivore population develop and subsequently reap the performance payments depends on a village's potential for collective action. Unfortunately, we lack village-level data on protective hunting which limits our ability to substantiate this reasoning. Among the indicators for collective action, group size was most significant and suggested that there is a negative relationship between group size and conservation success. Concerning the payment distribution rule, the regression results pointed to a positive relationship between the allocation of performance payments directly to individuals and increased lynx conservation.

Concerning the second question of how villages' internal benefit distribution rules come about, this paper presented a model based on which we could derive hypotheses for empirical testing. The main empirical findings are that, on average, a larger group size and prevailing differences in the likelihood of experiencing carnivore attacks on different winter pastures in a village will induce the village members to allocate a larger share of the performance payments directly to individual members. Although the rules governing the distribution of benefits of common pool resources are often stated to be an important determinant for the success of collective resource management (Ostrom 1990; Agrawal 2001), little work has previously been done on explaining how these rules emerge.

Looking at the results of both empirical parts of the paper, it is notable that group size impacts variation in lynx conservation outcomes across villages in two ways. On the one hand, the direct effect is negative, as predicted by collective action theory and shown in Table 3. On the other hand, by analyzing the payment distribution rule, we found that villages with more members allocate more of the performance payments directly to the herders, which has a positive effect on conservation outcomes. This result revises, at least in part, the general collective action hypothesis that an increase in group size necessarily has only negative effects on collective action.

Together with the significance of the payment distribution variable, this finding highlights the importance of investigating mechanisms leading to a specific benefit distribution rule in

common pool resource problems. The model we present to analyze the Swedish case could easily be adapted to other applications.

The empirical results of the study may be of particular interest to developers of REDD (Reduced Emissions for Deforestation and Degradation) projects since they face very similar challenges in jointly evaluating and rewarding groups of individuals. Although the inferences that can be made from our study may be restricted due to the lack of a counterfactual, we suggest that policymakers interested in group rewards pay attention to group internal distribution rules. With respect to REDD programs in developing countries, individual rewards may help circumvent elite capture, a problem that is of lesser concern in Sweden. Group size was found to be a particularly important factor in Sweden but other characteristics such as economic homogeneity, social capital, and exit options may play a greater role in other countries.

The Swedish case is a rare example of a performance payment scheme for biodiversity conservation. To enhance the understanding of this type of incentive mechanism, further research is necessary. In particular, the comparison to a region in which the policy is not implemented but that is very similar in all other characteristics would be ideal. Unfortunately, such a region is nonexistent for the Swedish case discussed in this paper. An interesting question for further research would also be to test the transferability of the performance payment approach to a developing country setting, particularly in the tropics, where wildlife-livestock conflicts are often especially severe. If attacks on livestock threaten the resilience of poor rural farmers, the latter have an incentive to hunt the damage-causing carnivores. In such cases, performance payments may be an appealing alternative to current, more conventional conservation policies.

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